

CLAIMS

What is claimed is:

1 1. A method for imaging contrast agents, comprising:
 2 transmitting power-modulated ultrasonic pulses comprising a predetermined
 3 transmit sequence having a plurality of transmit lines into a patient's body;
 4 receiving a plurality of ultrasonic echoes comprising contrast-agent generated
 5 echoes and tissue-generated echoes from the patient's body;
 6 processing the received ultrasonic echoes to generate a plurality of ultrasonic-
 7 echo signals responsive to both the contrast-agent generated and tissue-generated
 8 echoes;
 9 processing the plurality of ultrasonic-echo signals to suppress tissue-generated
 10 echoes;
 11 processing the plurality of ultrasonic-echo signals to suppress stationary
 12 contrast-agent generated echoes;
 13 applying the plurality of contrast-agent generated echo signals to a color-flow
 14 algorithm to generate a plurality of data points responsive to contrast-agent motion;
 15 and
 16 displaying the plurality of data points over time.

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1 2. The method of claim 1, wherein processing to suppress tissue
 2 generated signals comprises applying a finite-impulse-response (FIR) filter to the
 3 received ultrasonic echoes.

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1 3. The method of claim 1, wherein processing to suppress stationary
 2 contrast-agent generated echoes comprises applying a two-stage clutter filter to the
 3 received ultrasonic echoes.

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1 4. The method of claim 1, wherein the plurality of data points responsive
 2 to contrast-agent motion contain information related to direction of motion and
 3 relative velocity.

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- 1 5. The method of claim 1, wherein the plurality of transmit lines are
2 generated with transmit signals having different voltage amplitudes.
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- 1 6. The method of claim 1, wherein the plurality of transmit lines are
2 generated with transmit signals having different phases.
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- 1 7. The method of claim 1, wherein the plurality of transmit lines are
2 generated with transmit signals having different polarities.
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- 1 8. The method of claim 1, wherein the plurality of data points responsive
2 to contrast-agent motion contain information related to direction of motion and
3 relative velocity.
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- 1 9. The method of claim 2, wherein a plurality of first coefficients are
2 applied to the received ultrasonic echoes.
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- 1 10. The method of claim 4, wherein displaying is performed after a
2 determination that the intensity of the velocity information exceeds a threshold.
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- 1 11. The method of claim 4, wherein displaying is performed after
2 correcting the velocity information for tissue motion.
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- 1 12. The method of claim 9, wherein a plurality of second coefficients are
2 applied to the received ultrasonic echoes.
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- 1 13. The method of claim 10, wherein B-mode image data is displayed after
2 a determination that the intensity of the velocity information fails to meet the
3 threshold.
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1 14. An ultrasound-imaging system, comprising:
2 means for reducing tissue-generated ultrasonic echo signals;
3 means for reducing stationary contrast-agent generated ultrasonic-echo signals;
4 and
5 means for imaging moving contrast-agent generated ultrasonic-echo signals.

1 15. The system of claim 14, wherein reducing tissue-generated ultrasonic
2 echo signals comprises a power-modulation technique that uses multiple-transmit line
3 subpackets.

1 16. The system of claim 14, wherein imaging comprises applying the
2 moving contrast-agent generated ultrasonic-echo signals to a color-flow processor.

1 17. The system of claim 14, wherein reducing stationary contrast-agent
2 generated ultrasonic-echo signals comprises applying a first clutter filter.

1 18. The system of claim 15, wherein the power-modulation technique
2 comprises repetitively firing the multiple-transmit line subpackets.

1 19. The system of claim 16, wherein the color-flow processor generates
2 information responsive to the direction and the rate of motion of moving contrast
3 agent.

1 20. The system of claim 17, wherein the first clutter filter comprises a one-
2 zero filter.

21. The system of claim 20, wherein the one-zero filter is time-shifted filter over multiple samples generated from a plurality of ultrasonic-echo signals.

1 22. The system of claim 21, further comprising:
2 means for determining tissue velocity, and
3 means for combining the tissue velocity with the information responsive to the
4 direction and the rate of motion of moving-contrast agent.

1 23. The system of claim 22, wherein determining tissue velocity comprises
2 applying the received ultrasonic-echo signals to a second clutter filter prior to the
3 means for reducing tissue-generated ultrasonic-echo signals.

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1 24. An improved ultrasound-imaging system, comprising:
2 an excitation-signal source configured to generate a power-modulated
3 transmit-line sequence;
4 a transducer coupled to the excitation-signal source, the transducer configured
5 to emit a plurality of ultrasonic-pulses responsive to the power-modulated transmit-
6 line sequence into a medium and to convert a plurality of received ultrasonic echoes
7 responsive to both tissue and one or more contrast agents within the medium to a
8 plurality of echo signals;
9 an ultrasound-processing system coupled to the transducer, the ultrasound-
10 processing system configured to reduce tissue-generated ultrasonic-echo signals and
11 reduce stationary contrast-agent generated ultrasonic-echo signals, while passing
12 ultrasonic-echo signals generated from moving contrast agent; and
13 a display-processing system coupled to the ultrasound-processing system, the
14 display-processing system configured to receive and generate a graphic representation
15 responsive to the ultrasonic-echo signals generated from moving contrast agent.

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1 25. The system of claim 24, wherein the power-modulated transmit-line
2 sequence is generated with transmit signals having different voltage amplitudes.

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1 26. The system of claim 24, wherein the power-modulated transmit-line
2 sequence is generated with transmit signals having different polarities.

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1 27. The system of claim 24, wherein the power-modulated transmit-line
2 sequence is generated with transmit signals having different phases.

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1 28. The system of claim 24, wherein the ultrasound-processing system
2 comprises a clutter filter.

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1 29. The system of claim 28, wherein the ultrasound-processing system
2 comprises a plurality of two-dimensional imaging processors.

1 30. The system of claim 29, wherein the ultrasound-processing system
2 comprises a color-flow processor.

1 31. The system of claim 28, wherein the clutter filter comprises a multiple
2 sample one-zero filter.

1 32. The system of claim 31, wherein the clutter filter time shifts the zero
2 between adjacent ultrasonic-echo signal samples.

1 33. The system of claim 32, further comprising:
2 a tissue-velocity processor coupled to the ultrasound-processing system, the
3 tissue-velocity processor configured to generate a first output signal responsive to
4 motion of tissue-generated ultrasonic-echo signals;
5 an arbiter coupled to a second output signal from the color-flow processor and
6 a third output signal from at least one of the plurality of two-dimensional image
7 processors, the arbiter configured to forward the second output signal from the color-
8 flow processor when the intensity of the second output signal exceeds a threshold; and
9 an arithmetic junction coupled to an output of the arbiter and the first output
10 signal, the arithmetic junction configured to perform a subtraction of the first output
11 signal from the second output signal.

1 34. The system of claim 33, wherein the arbiter is configured to forward
2 the third output signal from at least one of the plurality of two-dimensional image
3 processors when the intensity of the second output signal fails to exceed a threshold.